

REMARKS

The Applicants thank the Examiner for the thorough consideration given the present application. Claims 5-11, 15, 18, 20, 23, and 35-38 were previously cancelled. Claims 1-4, 12-14, 16, 17, 19, 21, 22, 24-35 are pending. Claims 1, 4, 12, 14, 16, and 34 are amended. Claim 1 is independent. The Examiner is respectfully requested to reconsider the rejections in view of the remarks set forth herein.

Examiner Interview

If, during further examination of the present application, a discussion with the Applicants' Representative would advance the prosecution of the present application, the Examiner is encouraged to contact Carl T. Thomsen, Registration No. 50,786, at 1-703-208-4030 (direct line) at his convenience.

Rejections Under 35 U.S.C. §103(a)

Claims 1-4, 11-14, 16, 17, 19, 21, 24-26, 28-31, 33, and 34 stand rejected under 35 U.S.C. §103(a) as being unpatentable over GB 2161647 in view of Buchanan et al. (U.S. 4,283,228) and further in view of Fernandez et al.;

claims 5-10 and 15 stand rejected under 35 U.S.C. §103(a) as being unpatentable over GB 2161647 in view of Buchanan and further in view of Fernandez et al. and either of Akiyama et al. or Thiele et al.;

claim 22 stands rejected under 35 U.S.C. §103(a) as being unpatentable over GB 2161647 in view of Buchanan et al., and further in view of Fernandez et al. and Maas et al.;

claim 27 stands rejected under 35 U.S.C. §103(a) as being unpatentable over GB 2161647 in view of Buchanan et al., and further in view of Fernandez et al. and Yao et al.; and

claim 32 stands rejected under 35 U.S.C. §103(a) as being unpatentable over GB 2161647 in view of Buchanan et al., and further in view of Fernandez et al. and Chen et al.

These rejections are respectfully traversed.

Amendments to Independent Claim 1

While not conceding the appropriateness of the Examiner's rejection, but merely to advance the prosecution of the present application, independent claim 1 has been amended to recite a combination of steps directed to a method of producing a piezoelectric ceramic thick film on a substrate, said method comprising:

- mixing liquid phase precursors of Li₂O and Bi₂O₃ metal oxides to form a Li-Bi solution;
- forming a suspension of a piezoelectric ceramic material in powder form and a fluid medium by ultrasonic vibration;
- forming a liquid mixture by mixing the suspension of powdered material with the Li-Bi solution, the Li₂O and Bi₂O₃ having melting points lower than a temperature required for densifying the piezoelectric ceramic thick film by sintering, said liquid mixture obtained by mixing the suspension of powdered material and the Li-Bi solution having a greater degree of homogeneity than that of a mixture obtained by mechanically mixing the powdered material.

The Applicants respectfully submit that the combination of method steps as set forth in independent claim 1 is not disclosed or made obvious by the prior art of record, including GB 2161647 in view of Buchanan (U.S. 5,318,725) and further in view of Fernandez et al.

Regarding GB2161647A

In GB2161647A, a powder of glass-like binding agent was added to the piezoelectric ceramic powder (Pg 1, Line 98; Pg 2, Line 48). However, the homogeneity achieved through mechanically mixing the powder of the binding agent with piezoelectric ceramic powder is limited, particularly when the amount of the binding agent is small.

Moreover, the Examiner concedes that the GB2161647A document fails to teach a liquid phase precursor of metal oxide for a binding agent. Thus, GB2161647A cannot teach or suggest “said liquid mixture obtained by mixing the suspension of powdered material and the Li-Bi solution having a greater degree of homogeneity than that of a mixture obtained by mechanically mixing the powdered material”, as in independent claim 1.

Regarding Buchanan et al.

Buchanan et al. (U.S. 4,283,228) merely disclose bulk ceramic processing, which is different from the thick film processing as set forth in claim 1 of the present invention. Furthermore, in the description of U.S. 4,283,228, in all the embodiments only the process of using V₂O₅ solid oxide suspended in a solvent or liquid (as a dispersant), but is not dissolved. In particular, refer to the second embodiment in which V₂O₅ is merely used as a sintering aid for the PZT powder. (See Buchanan et al. column 3, lines 25-35, for example.) The V₂O₅ is

dispersed as a solid particle, which is different from the liquid phase precursors of Li_2O and Bi_2O_3 metal oxides as in independent claim 1. Although Buchanan et al. (U.S. 4,283,228) mention ammonium vanadate or vanadyl salts in general terms in Lines 6-11 in Column 2, these chemicals are simply used as a reactant with PZT as in the first embodiment, and Buchanan et al. (U.S. 4,283,228) do not show how to use their liquid phase to realize a uniform mixing of V_2O_5 with PZT powder when the V_2O_5 are used as a sintering aid as in the second embodiment.

The ceramic powder used to prepare the paste for thick film printing in the present invention is also different from that of Buchanan et al. (U.S. 4,283,228) for bulk ceramic.

In the present invention, the ceramic powder comprises the “precipitated” piezoelectric ceramic particles from the suspension and the metal organics at the surfaces of the ceramic particles as the sintering aids. Such precipitated ceramic particles tend to aggregate seriously. Although the piezoelectric ceramic particles and the metal oxides as the sintering aids have been uniformly mixed through the liquid phase approach, the present invention sets forth the step of “milling the dried precipitate to form a powdered precipitate” is essential, followed by the additional step of “further milling the powdered precipitate to form a paste”.

Regarding Fernandez et al.

Fernandez et al. were cited merely to disclose organic carriers on Al_2O_3 and milling to form a paste. Fernandez et al. make no mention of “milling the dried precipitate to form a

powdered precipitate", followed by "further milling the powdered precipitate to form a paste".

As set forth on page 3, lines 16-29 of the original specification, an object of the present invention is to overcome the problems of the conventional art, in which the conventional mixing methods of ceramic powder have resulted in a significant lack of homogeneity in the distribution of the metal oxide powder in the as-deposited film.

Only the present invention discloses that the metal oxides as the sintering aids maintain their homogeneous distribution after the two mechanical millings, and that a quality thick film can still be obtained through the printing and annealing the ceramic paste. None of the cited references teaches or suggests this. Until the disclosure of the present invention, there was no known method of preventing the out-separation of the metal oxides of the sintering aid from the ceramic powder due to their different specific weights during milling or due to possible dissolution of the metal oxides in the organic carrier for printable thick film paste.

Moreover, on page 5 of the Office Action, the Examiner concedes the references fail to specifically recite the claimed compounds, and alleges that one skilled in the art would have had a reasonable expectation of similar success regardless of the particular compounds utilized, including Li_2O and Bi_2O_3 . In response, the Applicants respectfully submit that not only do the cited references fail to disclose the particular compounds set forth in independent

claim 1, the cited references also fail to teach or suggest each and every step of the present invention including

“liquid mixture obtained by mixing the suspension of powdered material and the Li-Bi solution having a greater degree of homogeneity than that of a mixture obtained by mechanically mixing the powdered material”,

followed by the step of “milling the dried precipitate to form a powdered precipitate”, which in turn is followed by the step of “further milling the powdered precipitate to form a paste”, as set forth in independent claim 1, as amended herein.

As such, the Applicants respectfully submit that the examiner has failed to establish a *prima facie* case of obviousness, based on the combination of GB 2161647, Buchanan et al. (U.S. 4,283,228), and Fernandez et al.

At least for the reasons explained above, the Applicants respectfully submit that the combination of method steps as set forth in independent claim 1 is not disclosed or made obvious by the prior art of record, including GB 2161647, Buchanan et al., and Fernandez et al.

Therefore, independent claim 1 is in condition for allowance.

Dependent Claims

The Examiner will note that dependent claims 4, 12, 14, 16, and 34 have been amended in order to place them in better form.

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All dependent claims are in condition for allowance due to their dependency from allowable independent claims, or due to the additional novel features set forth therein.

Accordingly, reconsideration and withdrawal of the rejections under 35 U.S.C. §103(a) are respectfully requested.

CONCLUSION

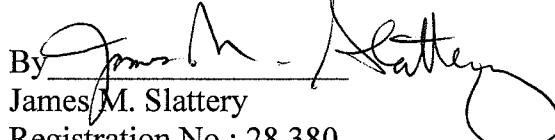
All of the stated grounds of rejection have been properly traversed, accommodated, or rendered moot. It is believed that a full and complete response has been made to the outstanding Office Action, and that the present application is in condition for allowance.

If the Examiner believes, for any reason, that personal communication will expedite prosecution of this application, he is invited to telephone Carl T. Thomsen (Reg. No. 50,786) at (703) 208-4030(direct line).

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any additional fees required under 37 C.F.R. §§1.16 or 1.17, particularly extension of time fees.

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Respectfully submitted,

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